Appendix 4

Stock Assessment Principles and Terms

Much of the information in this document comes from the scientific analysis of fisheries data to develop stock assessments. **Stock assessment** includes an estimation of the amount or abundance of the resource, an estimation of the rate at which it is being removed due to harvesting and other causes, and one or more reference levels of harvesting rate and/or abundance at which the stock can maintain itself in the long term. Such assessments often contain short-term (1-5 years, typically) projections or prognoses for the stock under a number of different fishing and management scenarios. This information on resource status is used by managers to determine what actions are needed to promote the best use of our living marine resources.

Stock assessment analyses rely on various sources of information to estimate resource abundance and population trends. The principal information comes from the commercial and recreational fishery themselves. For example, the amount of fish caught, the individual sizes of the fish and their biological characteristics (e.g., age, maturity, sex), and the ratio of fish caught to the time spent fishing (catch per unit of effort) are basic data for stock assessments. In addition, NOAA Fisheries conducts resource surveys with specialized research vessels or chartered fishing vessels. These surveys, often conducted in cooperation with state marine resource agencies, universities, international scientific organizations, and fisheries agencies of other nations, produce estimates of resource abundance.

Research surveys are conducted differently from commercial fishing. While commercial operations seek out the greatest aggregations of fish and concentrate on them to obtain the largest or most valuable catch, research surveys fish in a standardized manner over a wide range of locations within the waters inhabited by the stocks to provide unbiased population abundance and distribution index year after year. The survey results are then used in conjunction with commercial and recreational catch data to assess the resource base. The final critical data comes from studies on the basic biology of the animals themselves. Understanding the natural history of the harvested species and the other species with which they interact is crucial to understanding dynamics of the resources.

Fish abundance or population size can be expressed as either the number of fish or the total fish weight (or "biomass"). Increases in the amount of fish are determined by body growth of individual fish in the population, and the addition or **recruitment** of new generations of young fish (i.e., "recruits"). Those gains must then be balanced against the proportion of the population removed by harvesting (called **fishing mortality, F**) and other losses due, for example, to predation, starvation, or disease (called **natural mortality, M**). In stock assessment work, removals of fish from the population are commonly expressed in terms of rates within a time period. The **fishing mortality rate** is a function of **fishing effort**, which includes the amount, type, and effectiveness of fishing gear and the time spent fishing.

Surplus production (or just "production") is the total weight of fish that can be removed by fishing without changing the size of the population. It is calculated as the sum of the growth in weight of individuals in a population, plus the addition of biomass from new recruits, minus the biomass of animals lost to natural mortality.

The **production rate** is expressed as a proportion of the population size or biomass. The production rate is highly variable owing to environmental fluctuations, predation and other biological interactions with other populations. On average, production decreases at low and high population sizes. Thus, surplus production tends to be low at the extremes of population size (i.e. where biomass or production rate is low). It is more likely to be high at some intermediate level of population biomass. But, on average, biomass decreases as the amount of fishing effort increases. This means there is a relationship between average production and fishing effort. This relationship is known as the **production function**.

Production functions are the basis for certain important concepts used in this report: **Long-term Potential Yield** (LTPY), **Current**

Potential Yield (CPY), and **Recent Average Yield** (RAY). In addition, the term **Stock Level** is employed as a biological reference for determining resource status relative to the stock level which would on average support the LTPY. Recent Average Yield also is reported in order to allow comparison of the current situation to long-term potential.

Long Term Potential Yield (LTPY)

LTPY is the maximum long-term average yield that can be achieved through conscientious stewardship, by controlling **F** through regulating fishing effort or total catch. LTPY is a reference point for judging the potential of the resource. However, it is not necessarily the goal of management to always take the maximum yield. Other factors influence the choice of a management objective, such as socioeconomic considerations or conservation and ecosystem concerns for other resources indirectly affected by fishery harvests. LTPY may be controversial to estimate. Nevertheless, NOAA scientists have used their best professional judgment to provide these figures as a gauge of long-term production potential whenever possible.

Current Potential Yield (CPY)

CPY, the current potential catch that can be safely taken, depends on the current abundance of fish and population dynamics of the stock. It is usually estimated by applying F associated with LTPY (e.g., target fishing effort) to the current population size. This yield may be either greater than or less than LTPY. CPY is the amount of catch that will maintain the present population level (biomass) or, for overutilized stocks, stimulate a trend toward recovery to a population size that will produce the LTPY. For stocks at high biomass levels, the CPY may be larger than the LTPY. In this circumstance a large fishery harvest would not be sustainable in the long run, but it would bring the stock down to the level supporting LTPY.

Recent Average Yield (RAY)

RAY is equivalent to recent average catch. Unless designated otherwise, RAY is the reported fishery landings averaged for the most recent three-year period, 1992-94.

Stock Level Relative to LTPY

To further clarify resource status, stock level (i.e., abundance) in the most recent year is compared with the level of abundance which on average would support the LTPY harvest. This is expressed as being **Below, Near**, **Above or Unknown** relative to the LTPY stock level. In some cases, heavy fishing in the past reduced a stock to a low abundance, and even if the stock currently is harvested only lightly, it may take many years for it to rebuild.

Status of Utilization

In this report, a resource is classified as **underutilized, fully utilized, overutilized, or unknown** as a qualitative measure of the level of use. This is derived by comparing the present levels of fishing effort and stock abundance to those levels necessary to achieve LTPY.

It may differ from some evaluation of a fishery required under the MFCMA and the accompanying guidelines for preparations of Fishery Management Plans. Each management plan contains a specific definition of overfishing which is used for management purposes. The MFCMA national standards require management plans to be designed to give the highest continuing yield possible as modified by social and economic factors. In practice, this means each management plan may have different goals and hence different definitions of overfishing. As this report is intended to provide a broad overview across all fisheries, we use the more comparable measures of fishery conditions described below. These characterizations with respect to recent stock levels and fishing effort are in no way intended to supplant the specific definitions used to trigger management actions contained in fishery management plans.

A fishery resource is defined as **fully utilized** when the amount of fishing effort used is about equal to the amount needed to achieve LTPY and where the resource is near its LTPY stock level. For fully utilized fisheries, the RAY and CPY are usually about equal. In most cases, LTPY and CPY are also about equal, but they may differ as a result of production variability. A fishery resource is considered **overutilized** when more fishing effort is employed than is necessary to achieve LTPY. When RAY is greater than CPY, and CPY is less than LTPY, overutilization is indicated. If stock abundance is near the level that on average produces LTPY,

RAY may be greater than LTPY for an overutilized stock, implying that recent landings levels cannot be sustained. If stock abundance is below the level associated with LTPY, RAY will likely be less than LTPY.

Additionally, it is possible for RAY, CPY, and LTPY to be about equal while the fishery resource is overutilized. This occurs when reducing fishing effort would have little effect on the amount of catch realized. In such cases, overutilization may not have an apparent adverse effect on production, but it further reduces the size of the population, it wastes effort and economic resources, and imposes other deleterious consequences (e.g., excessive bycatch, gear interactions).

A fishery resource is classified as **underutilized** when more fishing effort is required to achieve LTPY. This situation is generally indicated when RAY is less than CPY and CPY is greater than LTPY while stock level is above the reference level that on average produces LTPY. But there may be exceptions. For example, RAY may be held below CPY and LTPY by management to compensate for uncertainty in population estimates and ecosystem considerations.

These are the major factors NOAA Fisheries considers for determining the status of resource utilization for this report, but they may not always give a complete picture. In cases where knowledge about the stock is incomplete or the classification of a fishery's status is based on the best scientific judgment of the NOAA scientists that conducts research on the stock in question.

For many stocks, LTPY or CPY may be unknown. For the purpose of reporting total LTPY and CPY across resources within the various fishery units and for the Nation as a whole, if CPY were unknown RAY was substituted when calculating a unit, regional, or national total CPY. If LTPY were unknown CPY was substituted, or, failing that, RAY was substituted in calculating totals.

In many of the fishery units, a dollar figure is given for the ex-vessel revenue generated by the commercial fishery on a given stock or group of stocks. **Ex-vessel revenue** is defined as the quantity of fish landed by commercial fishermen multiplied by the average price received by them at the first point of sale. As such, ex-vessel revenue captures the immediate value of the commercial harvest, but does not reflect multiplier effects of subsequent revenues generated by seafood processors, distributors, and retailers.

The estimate of "economic value" often takes both recreational and commercial catches and multiplies them by an average price to arrive at a baseline measure of economic worth among various user groups. It may underestimate those fisheries where there is a large recreational component. Nevertheless, the value serves as a useful gauge of relative potential revenues generated over many disparate stocks, fisheries, and regions.

Marine Mammal and Sea Turtle Assessments

The same scientific principles apply to the population dynamics of these protected species, but the terminology of underutilized, fully utilized, and overutilized does not apply. Instead, marine mammals are referred to as **Depleted** when their population size is below the level of **maximum net production**. This is often referred to as their "**optimum sustainable population level**."

The MMPA defines OSP to mean "with respect to any population stock, the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element." For operational purposes, NOAA Fisheries and the USFWS have interpreted this definition to mean "a population size falling within a range from the population level of a given species or stock which is the largest supportable within the ecosystem to the population level that results in maximum net productivity (MNP)." Maximum net productivity is defined as "the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less loses due to natural mortality."

Protected marine mammals and turtles may also be classified as **threatened** or **endangered** under the ESA. A species is considered threatened if it is likely to become an endangered species in the foreseeable future throughout a significant portion of its range. A species is considered endangered if it is in danger of extinction throughout a significant portion of its range. In addition to some marine mammals and all sea turtles, several Pacific salmon stocks are now listed as threatened or endangered. ❑